Completed Project (2011 - 2014)

Integrated Ground Operations Demonstration Units Project

Advanced Exploration Systems Program | Human Exploration And Operations Mission Directorate (HEOMD)

ABSTRACT

The overall goal of the AES Integrated Ground Operations Demonstration Units (IGODU) project is to demonstrate cost efficient cryogenic operations on a relevant scale that can be projected onto future Spaceport architectures and extraterrestrial surface operations.

The results of this project are being incorporated and built on in the AES Autonomous Propellant Loading project.

ANTICIPATED BENEFITS

To NASA funded missions:

The project can realize: 1) Reduced costs due to elimination of cryogenic propellant boiloff and reduction of transportation/distribution losses, 2) Enabling practical use of densified propellant operations to increase launch vehicle performance, 3) Reduction of helium use for liquid hydrogen propellant operations (conserving a finite natural resource and reducing operations costs), 4) Reduced labor costs and increased safety during hazardous cryogenic propellant loading operations, and 5) Lower system maintenance cost by implementing automated system health management.

To NASA unfunded & planned missions:

The project can lower the life cycle costs for launch operations, thereby reducing cost of access to space, enabling more budget allocation for science and exploration initiatives. The project can enable more autonomous operations for human exploration of other planetary bodies by reducing crew work load and reliance on mission operations support from Earth.

To other government agencies:

Other govenrment agencies (primarily DoD) that use cryogenic propellants are interested in both autonomous cryogenic liquid handling and zero-loss handling. Those agencies that use liquid hydrogen are interested in densification for performance

Integrated Ground Operations Demonstration Units (IGODU)

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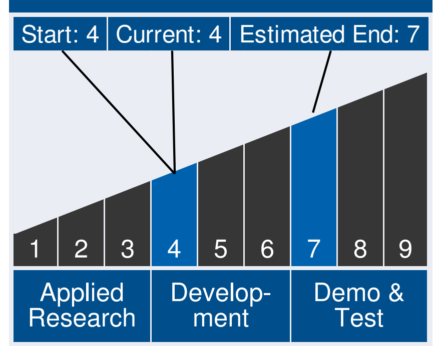
Technology Maturity



Management Team

Program Director:

- Jason Crusan

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improvement.

To the commercial space industry:

The commercial space industry is interested in lowering launch infrastructure and operations costs for propellant operations. This technology will also be used for the multi-use spaceport at KSC.

To the nation:

This project will increase safety and reduce the cost of access to space by automating cryogenic propellant handling/loading of launch vehicles while reducing loss of propellant storage and handling.

DETAILED DESCRIPTION

The overall goal of the project is to demonstrate cost efficient cryogenic operations on a relevant scale that can be projected onto future Spaceport architectures and extraterrestrial surface operations. This goal will be demonstrated by completing the primary test objectives below:

- GODU Integrated Refrigeration and Storage (IRAS)
- Demonstrate zero loss storage and transfer of LH2 at a large scale.
- Demonstrate hydrogen densification in storage tank and loading of flight tank
- Demonstrate in situ hydrogen liquefaction using helium refrigeration GODU Autonomous Control of Cryogenic Propellant Load
- Demonstrate autonomous control of a sub-scale vehicle loading operation
- Demonstrate recognition of common system faults and anomalies and recover without human intervention

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Management Team *(cont.)*

Program Executive:
- Richard Mcginnis

Project Manager:
- Robert Johnson

Principal Investigator:
- Robert Johnson

Technology Areas

Primary Technology Area:
In-Space Propulsion Technologies (TA 2)
└ Supporting Technologies (TA 2.4)
  └ Propellant Storage and Transfer (TA 2.4.2)
    └ Active Thermal Control (TA 2.4.2.2)

Secondary Technology Area:
In-Space Propulsion Technologies (TA 2)
└ Supporting Technologies (TA 2.4)
  └ Propellant Storage and Transfer (TA 2.4.2)
    └ Passive Thermal Control for Cryogenic Propellants (TA 2.4.2.1)

Robotics and Autonomous Systems (TA 4)

Human Exploration Destination Systems (TA 7)

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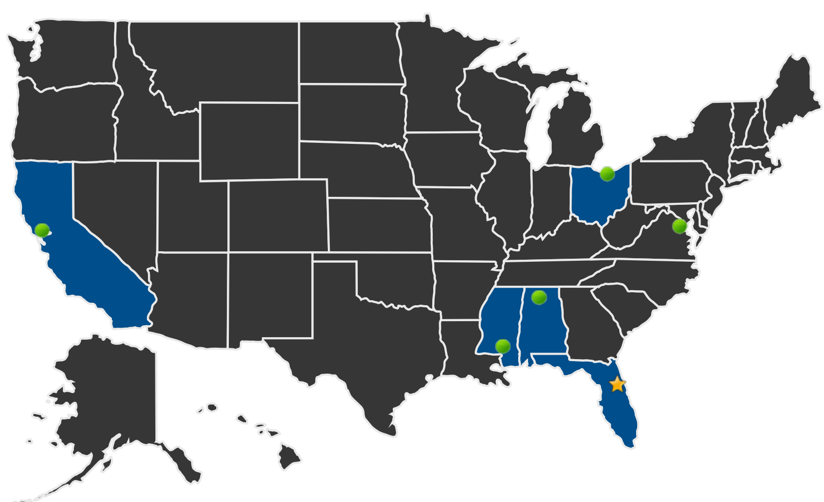
- Evaluate tools and techniques in real world application to advance health management and autonomous control technologies for future applications
- Demonstrate scalability and extensibility by replicating autonomous control of the 6,000 gallon LOX simulator system to the 33,000 gallon LH_2 system
- Develop and demonstrate helium conservation instrumentation and processes
- Provide potential hardware-in-the-loop demonstration capability for AES Automated Mission Operations project or other analog test environment for remote operations in 2014

U.S. WORK LOCATIONS AND KEY PARTNERS



U.S. States With Work

Lead Center: Kennedy Space Center

Technology Areas *(cont.)*

Nanotechnology (TA 10)
└ Engineered Materials and Structures (TA 10.1)
  └ Lightweight Structures (TA 10.1.1)
    └ Low Permeability Nanocomposites (TA 10.1.1.4)
    └ Nanoporous Thermal Insulation (TA 10.1.1.5)

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Supporting Centers:

- Ames Research Center
- Glenn Research Center
- Marshall Space Flight Center
- NASA Headquarters
- Stennis Space Center

Technology Areas ***(cont.)***

Ground and Launch Systems (TA 13)
- Operational Life-Cycle (TA 13.1)
  - On-Site Production, Storage, Distribution, and Conservation of Fluids (TA 13.1.1)
    - Low-Loss Storage of Cryogens Through Active Means (TA 13.1.1.3)
    - Higher-Efficiency Storage of Cryogens Through Passive Means (TA 13.1.1.4)
    - Higher-Efficiency Transfer of Cryogens Using Active Means (TA 13.1.1.5)
    - Higher-Efficiency Transfer of Cryogens Using Passive or Vacuum Jacket Means (TA 13.1.1.6)
- Reliability and Maintainability (TA 13.3)
  - Decision-Making Tools (TA 13.3.8)
    - Intelligent Procedures for Launch Operations Sequencing and System Troubleshooting (TA 13.3.8.1)

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Technology Areas *(cont.)*

Thermal Management Systems (TA 14)
- Cryogenic Systems (TA 14.1)
  - Passive Thermal Control (TA 14.1.1)
    - Load Responsive Insulation (TA 14.1.1.1)
    - Wrapped Insulation (TA 14.1.1.2)
    - Cooled Insulation for Reduced & Zero Boil Off (TA 14.1.1.4)
  - Active Thermal Control (TA 14.1.2)
    - High Capacity 20 Kelvin Cryocoolers (TA 14.1.2.1)
    - Distributed Cooling Loops (TA 14.1.2.5)
    - Integrated Radiator/Cryocooler for Liquefaction (TA 14.1.2.7)
    - Subcooling Cryogenic Propellants (TA 14.1.2.8)

DETAILS FOR TECHNOLOGY 1

Technology Title

Integrated Ground Operations Demonstration Units

Technology Description

This technology is categorized as complex electronics software for ground support or mission operations

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Capabilities Provided

Autonomous control of hazardous cryogenic propellant operations and new cryogenic propellant storage and distribution architecture to enable lower life cycle costs of ground and launch operations.

Zero-loss storage and transfer of liquid hydrogen.

Densification of liquid hydrogen. This increases launch vehicle performance.

New technologies and processes to conserve helium usage in ground and launch processing (an expensive, finite natural resource). This is budget dependent.

Potential Applications

Automated cryogenic propellant handling and loading for the Space Launch System and the Multi-purpose Spaceport at KSC.

Autonomous loading of vehicle propellants in space and at remote propellant depots, such as prepositioned in-space propellant stores or propellants positioned or produced on other planets or moons.